The presence of the high-pressure area over the central Plateau States caused cold-air drainage into California, and frosty mornings were of almost daily occurrence. The frosts did no great damage, as almost all the staple crops had been harvested before they occurred. In southern California the frosts were not so severe as they were farther north, and the orange and lemon crops on this account escaped serious injury.

No less than 23 frost warnings were issued for places in California and practically all of them were verified. Storm warnings were issued for different parts of this district on 18 occasions, and small-craft warnings were displayed on three days.

Only one cold-wave warning was issued, though more than one cold wave occurred. The others, in which the falls in temperature were sufficient to justify a cold-wave warning, in several instances were covered by predictions of colder or much colder weather, because the drop in temperature was somewhat greater than expected.

Generally the northern high-pressure areas that cause cold waves move into the United States east of the Rocky Mountains and therefore only slightly affect the weather in this district, but this year several moved directly south from British Columbia to the North Pacific States and thereby caused persistently low temperatures throughout this district for several days at a time.—*E. A. Beals.*

NORTHER IN THE CANAL ZONE.

The following letter, dated January 8, 1920, from the office of the chief hydrographer of the Canal Zone refers to the warning for "fresh to strong northerly winds next 36 to 48 hours" sent that office on the 29th:

The warning was timely and fully verified. The wind reached a maximum velocity of 30 miles an hour from the northeast on the 30th at Cristobal, with gusts up to 45 miles reported from the naval air station. Cape Mala reported maximum winds up to 60 miles an hour. Windy weather continued for several days.

In addition to serving the shipping interests, the naval air station at Coco Solo considers these warnings beneficial and necessary.

RIVERS AND FLOODS, DECEMBER, 1919.

By A. J. HENRY, Meteorologist.

DAMAGING FLOODS IN THE EAST GULF STATES.

Light rains fell in the northern portion of Mississippi, Alabama, and Georgia and in Tennessee on the 6th. These were followed by heavy rains on the 7th, especially in northern Alabama and northwest Georgia, and these in turn by still heavier rains on the 8th and 9th practically throughout Alabama and northwest Georgia. The rains ceased before midnight of the 9th. The daily amounts for representative stations in Mississippi, Alabama and Georgia are shown in Table No. 1 below. In Table 2 the rainfall for all stations in the Chattahoochee and other river basins in Georgia are given. These tables show that the intensity of the rains was greatest in northern Alabama on the 7th, southeastern Mississippi on the 8th, and central Alabama and northwest Georgia on the 9th. The rainfall was not uniformly heavy at all stations, the maximum for the 3 days being as much as 12 inches in local areas. From these areas as a center the fall diminished to the northwest and the southeast to 4 to 6 inches and even less.

TABLE 1.—*Daily precipitation (inches and hundredths—Midnight to midnight).*

1919.	Meridian.	Montgomery.	Birmingham.	Chattanooga.	Atlanta.	Augusta.
Dec. 7	2.54	2.20	4.12	0.81	2.70	0.70
8	6.75	1.64	3.39	1.24	3.34	.39
9	1.11	4.78	.81	.71	5.71	T.
Total	10.40	8.62	8.32	2.76	11.75	1.09

TABLE 2.—*Rainfall of Dec. 7 to 10, 1919, in Georgia.*

[Measurements made about 5 p. m., except at stations otherwise indicated.]

WATERSHED OF THE CHATTAHOOCHEE RIVER.

Stations.	Dec. 7.	Dec. 8.	Dec. 9.	Dec. 10.	Total.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Dahlonega	0.81	1.08	3.74	1.53	7.16
Gainesville	0.80	1.35	2.20	3.00	7.45
Canton	0.97	1.93	4.57	1.93	9.40
Norcross[2]	1.10	1.62	4.92	5.22	12.86
Atlanta[1]	2.70	3.34	5.71	.00	11.75
Lost Mountain	1.40	2.15	4.68	0.79	9.02
Newnan	1.01	1.80	2.12	4.20	9.13
West Point	0.24	2.70	3.33	2.50	8.77
Goat Rock	0.06	1.58	2.75	2.51	6.90
Talbotton	1.45	2.00	0.93	1.09	5.47
Columbus	0.04	0.03	2.48	0.87	3.42

[1] Measurements midnight to midnight.
[2] Measurements made daily at 7 a. m. mean local time.

TABLE 2.—*Rainfall of Dec. 7 to 10, 1919, in Georgia*—Continued.

WATERSHED OF THE FLINT RIVER.

Stations.	Dec. 7.	Dec. 8.	Dec. 9.	Dec. 10.	Total.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Atlanta[1]	2.70	3.34	5.71	0.00	11.75
Newnan	1.01	1.80	2.12	4.20	9.13
Griffin	0.00	5.08	1.33	3.00	9.41
Woodbury[2]	0.00	1.94	1.36	2.16	5.46
Butler	0.00	0.00	1.92	0.67	2.59
Marshallville	T.	T.	1.17	0.50	1.67
Talbotton	1.45	2.00	0.93	1.09	5.47
Montezuma[2]	0.00	0.00	0.25	0.95	1.20
Americus	0.00	0.00	0.10	0.52	0.62
Albany	0.00	0.15	0.00	0.07	0.22
Bainbridge	0.06	0.00	1.94	0.00	2.00

UPPER WATERSHED OF THE OCONEE AND OCMULGEE RIVERS.

Atlanta[1]	2.70	3.34	5.71	0.00	11.75
Griffin	0.00	5.08	1.33	3.00	9.41
Covington	0.00	3.60	1.00	3.60	10.00
Macon[1]	0.14	1.43	0.08	0.31	1.96
Athens	0.76	2.52	2.81	3.80	9.89
Greensboro		5.39			
Milledgeville[2]	T.	0.82	1.10	0.50	2.42

UPPER WATERSHED OF THE SAVANNAH RIVER.

Clayton					
Toccoa	0.78	0.99	3.32	3.82	8.91
Hartwell	0.87	1.68	3.78	1.24	7.57
Carlton	0.50	1.95	2.30	2.79	7.54
Point Peter					8.00
Lisbon	0.80	5.78	0.35	0.10	7.03
Washington	0.37	3.00	2.80	0.53	6.70
Augusta[1]	0.70	0.39	T.	0.36	1.45

[1] Measurements midnight to midnight.
[2] Measurements made daily at 7 a. m. mean local time.

The meteorological conditions associated with or responsible for these rains were in no wise remarkable, but the sequence in which they developed was the controlling factor. Stripped of all technical language, it may be said that the rainstorm of the 6th–7th was immediately followed by one of somewhat greater intensity which passed over the East Gulf States from west to east on the 8th–9th. The rainfall on the dates last named produced damaging floods in all streams of southeastern Mississippi, Alabama, and Georgia. The flood in the Alabama, at Montgomery and Selma, closely approached the greatest flood experienced within historic times, viz, that of April 1, 1886. The flood on the Black Warrior River at Tuscaloosa, however, fell

12 feet short of the greatest flood hitherto recorded. The flood on the Tallapoosa, of Alabama, was the greatest recorded since the beginning of observations in 1903. Serious inconvenience and distress was caused at Montgomery, Ala., by the flood waters. The overflow penetrated the city supply of drinking water, got into the machinery of the municipal power and light plants, and caused a shut down of all power and light service. Railway train service was also interrupted and cellars were flooded in a large part of the city.

Despite the early and repeated warnings, it was necessary to rescue by boat many people who had become marooned on points of high ground near the river. Five persons in Montgomery lost their lives in the flood through the overturning of small boats. The total loss of life elsewhere in the flooded districts was 14.

Table 3 has been prepared for the purpose of comparing the 1919 flood with previous floods. The table gives the highest known water and the stages of 6 of the great floods during recent years. The dates of the floods were selected with reference to the Montgomery record. It was subsequently enlarged to include the floods of 1912 and 1913, which were more severe in the rivers of Georgia than in those of Alabama, and on the other hand the floods of 1906 and 1909 were less severe in Georgia than in Alabama.

TABLE 3.—*Flood in East Gulf States, December, 1919.*

River and station.	Previous high water.	Date.	High water in flood of—							
			January, 1892.	March, 1906.	March, 1909.	March, 1912.	March, 1913.	July, 1916.	December, 1919.	Above or below previous high water.
	Feet.		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Chicasawhay:										
Enterprise, Miss...	36.0	May 27, 1909	.....	29.4	36.0	27.1	23.6	28.1	36.0	— 0.2
Black Warrior:										
Tuscaloosa, Ala ...	68.6	Apr. 18, 1900	59.9	59.3	63.8	57.2	58.2	66.3	56.6	—12.0
Coosa:										
Lock No. 4, Ala...	24.1	July 16, 1916	.....	22.2	22.7	18.5	16.5	24.1	18.3	— 5.8
Wetumpka, Ala...	61.7	Apr. 1, 1886	.....	51.5	51.3	44.8	46.4	51.5	55.6	— 6.1
Tallapoosa:										
Millstead, Ala.....	48.2	Mar. 16, 1912	.....	42.8	42.2	48.2	44.0	39.8	[1] 54.0	+ 5.8
Alabama:										
Montgomery, Ala..	59.7	Apr. 1, 1886	54.0	50.2	51.7	44.9	48.1	51.7	57.1	— 2.6
Selma, Ala.....	57.0	Apr. 8, 1886	54.0	50.2	52.9	46.4	49.4	53.9	55.9	— 1.1
Chattahoochee:										
Norcross, Ga.....	19.7	July 11, 1916	.....	.....	.....	19.3	12.7	19.7	27.1	+ 7.4
West Point, Ga....	25.6	Mar. 31, 1886	.....	18.7	19.2	22.9	18.3	22.0	29.3	+ 3.7
Columbus, Ga.....	48.5	Mar. —, 1886	.....	.....	.....	.....	.....	41.9	52.0	+ 3.5
Eufaula, Ala.....	56.0	Mar. 28, 1888	.....	36.2	41.8	48.3	54.5	52.4	53.4	— 2.6
Alaga, Ala.....	44.0	July 9, 1916	.....	29.7	35.3	38.9	40.2	44.0	40.7	— 3.3
Flint:										
Albany, Ga.....	32.4	Mar. 25, 1897	.....	13.7	22.4	30.2	30.3	27.3	24.2	— 8.2
Oconee:										
Dublin, Ga.....	25.8	Mar. 5, 1902	.....	17.5	23.3	25.2	26.5	16.5	24.0	— 1.8
Ocmulgee:										
Macon, Ga.....	24.0	Aug. —, 1887	.....	17.0	20.4	22.7	23.6	23.1	25.3	+ 1.3
Savannah:										
Augusta, Ga.....	38.8	Aug. 27, 1908	32.8	28.6	28.0	36.8	35.1	28.4	35.4	— 3.4

[1] Estimated.

The following detailed description of the flood in rivers of Georgia has been supplied by Meteorologist C. F. von Herrmann, in charge of the Atlanta station of the Weather Bureau.

The area of heaviest precipitation was central in Fulton, Gwinett, and DeKalb Counties in northern Georgia, Norcross, in Gwinett County, receiving 12.86 inches in four days and Atlanta 11.75 inches. From this center the precipitation rapidly diminished toward the southeast and northwest, but extended from southwest to northeast over practically the entire watershed of the Chattahoochee River from Columbus to its most northern tributaries, and covered to a less extent the upper basins of the Flint, Oconee, Ocmulgee, and Savannah Rivers, as well as the tributaries of the Coosa, which join at Rome, Ga. Table 2 gives the actual rainfall over the most important watersheds.

Several noteworthy features concerning the December, 1919, floods at once attract attention. The heaviest rainfall must have covered a comparatively narrow stretch of country along the Chattahoochee from north of Columbus to Norcross, a distance of some 160 miles. This is made evident by the fact that the crest stages in the river at all three points, Norcross, West Point, and Columbus, were attained on the same day, and not only on the same day, but approximately about the same hour, namely, between 2 and 4 p. m. on December 10. In other words, the crest stages were caused by the water that entered the river in the immediate vicinity of each river station, rather than by the progress of the flood wave from upper to lower stations. Thus the very heavy rainfall telegraphed on the morning of December 10, covering the watershed from West Point northward, which, under ordinary circumstances, would have caused the steady movement of a crest from Norcross to Columbus during the next three days, had practically no further effect on the rivers already far above flood stage at all points and therefore spread out in many places to a width of 2 or 3 miles. Consequently, the flood in the Chattahoochee River was rapid, destructive, giving at two of the upper stations unprecedented high stages, which were maintained for an unusual duration of time. Thus the stage at Eufaula, Ala., remained above 50 feet (flood stage 40 feet) for no less than four days, from December 12 to 15, inclusive.

On the other hand, the absence of any considerable rainfall over the lower watershed of the Flint River gave rise to a very slow progress of a distinct flood crest from Woodbury, where it occurred on December 11, to Bainbridge on December 20, four days after the flood waters had swept out of the Chattahoochee.

The Savannah River at Augusta reached a stage of 35.4 feet on December 10, which is 3.4 above the flood stage, and may be compared with the high record of 38.8 feet in 1908. Owing to the great concrete levee separating the city from the flood waters the streets of Augusta, which formerly were badly flooded at stages as high as 34 feet, were quite dry, and no great damage occurred.

The flood in the upper Ocmulgee at Macon was severe. On December 11 and 12 the river was a raging flood, with an estimated velocity of 25 miles an hour. At 5.55 p. m. on December 12 the gage showed a crest stage of 25.3 feet, exceeding the preceding highest record by 1.3 feet. The lowlands on the east side of the river were entirely submerged and several houses were carried away, but as the authorities had been notified to move the inhabitants to the highlands no loss of life is known to have occurred. Many families had to camp out on high ground with the household effects that could be saved. The water was several feet deep over the Southern Railway near the Spring Street bridge and fears were entertained for the safety of the bridge, which was closed to traffic. The flood endangered the city water plant, but about 2 p. m. on December 11, the levee that protects Central City Park gave way, leaving a crevasse about 300 feet wide. This relieved the danger to some extent, for while the park and the Macon, Dublin & Savannah Railroad tracks were submerged, the backing up of the water below was to some extent prevented, and much property was saved that would otherwise have been lost. Great damage was done to the Central City Park and to the buildings and property of the State Fair Association.

The rise in the Flint River was not dangerous except in the extreme upper part of the watershed. Warnings were issued so far in advance of the flood wave for all points below Woodbury that there was ample time to take necessary precautions. At Woodbury the Flint attained an unprecedented stage of 17.1 feet on December 11. The crest was attained at Montezuma on the 13th, at Albany on the 18th, and at Bainbridge, where however, the flood stage was not quite reached, on the 20th. No great amount of damage was caused by the flood.

The Coosa River at Rome attained a stage of 32.8 feet on the 11th, as compared with a previous maximum stage at Rome of 40.3 feet in 1886. At Canton, on the Etowah, however, a crest stage of 24.3 feet was registered, which surpassed the previous maximum record of 23.9 feet in July, 1916. Some damage occurred at Rome to manufacturing plants near the river, water entered the basements of some houses, and a number of people had to move out of their homes.

THE FLOOD IN THE CHATTAHOOCHEE.

The rise in the Chattahoochee River north of Columbus surpassed all previous records in the history of the river. The increasing frequency of floods in the Chattahoochee River during the last 20 years as compared with the period of 20 years immediately preceding is very striking. At Norcross, some 20 miles north of Atlanta, the Chattahoochee River reached a crest stage of 27.1 feet at about 3 p. m. on December 10, or 7.4 feet higher than the July, 1916, record. This extraordinary rise imperiled the waterworks system of the city of Atlanta by threatening to flood the pumping station. The river attained a height of 5.9 feet above the top of the permanent dikes that protect the plant, and the danger was only averted by the strenuous efforts of laborers, volunteer workers, and convicts summoned by the county officials who, for 48 hours, piled hundreds of tons of clay and sand bags on top of the dikes to keep it above the rising flood. By the evening of December 10 the danger was past.

There can be no doubt that the greatest destruction occurred at the city of West Point, which is situated at the point where the Chattahoochee River begins to form the boundary between Georgia and Alabama. This is a thriving city of cotton mills and manufacturing plants, the business part of the city and many residences being built on the low ground near the river banks between the hills on the eastern and western banks of the river. At a stage of 22 feet the water enters the streets of the city; the sidewalks and stores are elevated above the streets proper some 3 or 4 feet. This place having experienced a rise to 25.6 feet in 1886 and again to 25 feet in December, 1901, merchants are prepared to elevate their goods to higher positions in the stores when floods are threatened. The river, however, on this occasion rose with such rapidity and reached such an unprecedented stage that in many cases the precautions taken were of no avail. The crest reached at West Point was 29.3 feet on the afternoon of December 10.

The entire business section of West Point was flooded. Manufacturing establishments, hotels, the Auditorium, churches, warehouses, general stores, and numerous residences were surrounded by a swiftly moving current of water from 5 to 10 feet deep. There was no loss of life, but several hundred people were marooned for some days. The highway bridge over the Chattahoochee which connects the two sides of the city and supported the big water main was carried away, so that the city was without drinking water. The telephone and electric-light systems, gas works, and street-car service were entirely put out of commission, entailing great loss to equipments. The loss of property as a whole, though not yet accurately fixed, is conservatively estimated to have exceeded a million dollars. For some days following the flood the distress at West Point was so great that Red Cross aid from Atlanta was rushed to the city and contributions of money poured in from neighboring cities.

The Chattahoochee at Columbus rose to the very high stage of 52 feet, surpassing the record of 1886 by 3.5 feet. A great deal of damage was done to the machinery and stock of the cotton mills, iron foundries, grocery stores, and other commercial concerns along the river front. Electric light and street car service were suspended, and gas for cooking could not be obtained for some days. At Girard across the river in Alabama poorer people living in lowlands near the river had to vacate their homes. There was much enforced idleness owing to the impossibility of operating the mills.

Another feature of the flood was the enormous loss of river and smaller county bridges in at least a dozen counties within the region of greatest precipitation. The following counties suffered most severely: Fulton, Cobb, DeKalb, Rockdale, Spalding, Hall, and numerous others. On the night of December 9 while endeavoring to cross Utoy Creek near Atlanta an automobile was precipitated into the flooded creek, and three persons were drowned. The loss to crops gathered or prospective was very small, and to railroad property not great. An estimate of the total loss, including loss to buildings, factories, municipal plants, highways, and bridges, may conservatively be placed at nearly $2,000,000.

FLOODS IN THE MERIDIAN, MISS., RIVER DISTRICT, DECEMBER, 1919.

By J. H. JAQUA, Observer.

From December 8 to 9, 1919, more than 10 inches of rain fell over a narrow strip of territory in Mississippi, averaging approximately 50 miles in width, and extending northeastward from Lincoln County, in the southern portion of the State, to Kemper County, in the east-central portion, a distance of about 150 miles. The greatest depth of rainfall, somewhat over 12 inches, was in Lincoln and Lawrence Counties. To the northward and to the southward of the 10-inch area, the isohyets decrease rapidly to less than 4 inches. As the principal tributaries of the Chickasawhay, the Leaf, and lower Pearl Rivers originate in the region covered by excessive rains, the rise was extraordinary and unusually destructive in the upper watersheds of those streams.

The rise in the two uppermost reaches of the Chickasawhay River, Sowashee Creek and Chunky Creek, was the greatest of record. According to reliable marks, the overflow of Sowashee Creek, at Meridian, on the 8th–9th, was about 16 inches above any previous known mark, but southward from Meridian and from Chunky, on Chunky Creek, the crest stages were progressively lower than in the record flood of April, 1900. The stages in the upper Chickasawhay were from 8 to 12 inches below the heights reached in April, 1900, and were generally slightly lower than the stages reached in May, 1909.

Sowashee Creek, which is usually an insignificant stream, became, on the night of the 8th, a raging river of no mean proportions, threatening destruction to a large area in Meridian and its suburbs. The lower levels of the city and the districts to the southward were inundated until noon of the 9th. In this district it was necessary to transport hundreds of Negroes to higher ground, many of the victims being awakened by rescuers when the rising waters had already entered their dwellings. One person was drowned in rescue work.

The losses to individuals were not large in the aggregate, but many of the poorer families lost their hogs, chickens, and, in a few instances, their household effects.

All railroads in Lauderdale County suffered heavily by washouts, suspending traffic for two days. Many county bridges were washed out, and the damage to hard-surfaced roads was considerable, especially in the direction of Arundel. About three-fifths of the loss in the Meridian section is represented by damage to buildings, highways, and bridges.

Damage in the Chickasawhay Valley.—The crest stage reached at Enterprise was 37 feet, at 1 a. m. of the 10th, or 1 foot below the record stage. On the night of the 8th, the merchants began to elevate their stocks of goods to levels above average high water, but in spite of these precautions much damage was done to merchandise in storehouses.

The rise at Shubuta was 11.4 feet during the night of the 8th to a stage of 33 feet at 7 a. m. of the 9th, and at 1 p. m. of the 11th a crest stage of 44.3 feet was reached. As it was impossible, after 7 a. m. of the 9th, to reach the bridge upon which the river gage is located, the crest reading was derived by comparison with the record water mark of 45 feet, in April, 1900, the recent stage being about 8 inches lower.

Great damage occurred in the districts between Enterprise and Shubuta. Most of the inhabitants of lowlands suffered severely, somewhat more than 200 families, chiefly colored, near Shubuta, being obliged to abandon their homes, which were flooded to depths ranging from 3 to 4 feet for about two days. These families lost nearly all of their corn, peas, potatoes, and live stock, in addition to damage to household effects. It appears that the greater portion of the losses could have been avoided had the sufferers heeded the warnings, which were two days in advance of the flood. The river observer at Shubuta states that, "still with all the warnings they would not believe that it would be as it proved to be."

Railroad washouts were numerous along the Chickasawhay. In some instances from 300 to 500 feet of roadbed were undermined. Traffic was suspended for two days and complete resumption was not accomplished for nearly 10 days after the water receded. The Mobile & Ohio Railroad Co., by "tieing" its tracks at critical points, avoided the disaster of April, 1900, when their tracks were hurled into the woods for much of the distance from Meridian southward.

From Shubuta southward, the damage was less severe than in Clarke County, but there was a heavy loss of live stock and lumber, and great damage to roads, creek bridges, and fences.

Leaf River district.—The Leaf River, at Hattiesburg, reached a crest stage of 25.3 feet on the 11th, the highest since regular readings began. The loss by overflow and backwater at Hattiesburg and adjacent localities was probably greater than in any other section of equal area.